Effect of task related circuit training on walking ability in a Multiple Sclerosis subject. A single case study

Damayanti Sethy*, Pankaj Bajpai and Eva Snehlata Kujur
Department of Occupational Therapy, NIOH, Kolkata, West Bengal, India

Abstract. Objective: To investigate the effectiveness of task related circuit training on walking ability in a Multiple Sclerosis subject.
Method: Baseline measurement of lower limb muscle strength, speed test, Timed “Up and Go” test and 6-minute walk test. Modified fatigue impact scale and Expanded Disability Status Score were taken. After baseline measurement, subject was explained the sequence of tasks to be used in circuit training and the subject was given task related circuit training for 12 weeks. Post training measurements for all the outcome measures were taken.
Setting: Department of Occupational Therapy, NIOH, Kolkata, West Bengal, India.
Participant: A 34-year-old male.
Intervention: Task related Circuit training for a session of 45 minutes, 3 days per week for 12 weeks.
Results: The subject showed improvement in speed test, step test, 6-minute Walk Test. Also, fatigue was reduced. The walking ability of the subject improved, with increase in muscle strength, endurance, and physical fitness.
Conclusion: Task-related circuit training is effective in improving muscle strength and endurance, and in decreasing the fatigue of the subject thereby improving the subject’s ability to walk.

Keywords: Fatigue, Multiple Sclerosis, strength, endurance

1. Introduction
Multiple Sclerosis (MS) is a degenerative inflammatory disease of the Central Nervous System, which may involve the brain, optic nerve and spinal cord [30]. MS is the most common progressive neurologic disorder in young adults [14] and is usually diagnosed between the ages of 20 and 40 years [17]. MS is thought to be an autoimmune disorder that leads to the destruction of the myelin, oligodendrocytes, and axons [16]. Functional impairment in multiple sclerosis such as abnormal walking mechanics, poor balance, muscle weakness and fatigue typically result from axonal degeneration and conduction block [28]. These and other symptoms reduce individual’s ability to perform Activities of daily living. Muscle weakness and fatigue contribute to reduced daily activity in persons with MS. Inactivity further compromises muscle function, ambulatory ability and physical fitness. The vicious cycle of decreased activity contribute to increased disability and reduced quality of life [17].

Therapeutic strategies to promote improvements in muscle strength and endurance are desirable in individuals with multiple sclerosis [1]. Strength training is known to promote neural adaptations such as improved motor unit activation and synchronization of firing rates, which may deteriorate with periods of inactivity [13]. Neural adaptations gained through physical activity may have favorable functional outcome in MS subjects depending on lesion load and location [17].
White et al. in their study found that MS Patients are capable of making positive adaptations to resistance training that are associated with improved ambulation and decreased fatigue [28]. Dalgas et al. found that endurance training at low to moderate intensity and resistance training can be tolerated and have beneficial effects on multiple sclerosis patients [6].

Snook and Motl cited in their study that exercise training is associated with small improvements in walking ability in young individuals with multiple sclerosis [26]. Dodd et al., in a qualitative study in with multiple sclerosis found that progressive resistive exercise might be a form of strenuous physical activity that could address the common impairment of muscle weakness in multiple sclerosis without leading to unwanted negative effects, such as exacerbation of neurological signs and symptoms [9]. Debolt and McCubbin in their study found that a home based exercise training program was well tolerated by subjects with MS and increased their lower limb muscle strength [7].

Through research it has been found that practice of an exercise will not generalize into improved performance of functional task even with learner who has no motor control deficits [18]. So rehabilitation of MS patients should be based on training of everyday actions using information from biomechanics and motor learning as well as knowledge of the pathology of impairment associated with MS.

Training of MS patient can be organized into a circuit with a series of a work station designed to strengthen affected muscle providing the opportunity for task practice which will improve locomotion [3].

Circuit training is a highly efficient form of training having many work stations. Work stations are alternated so as to give rest to different muscle groups. Each muscle group is given more time to rest before it starts working again. It improves strength and endurance by stressing aerobic and anaerobic system. Evidence exists for recommending participation in endurance training at low to moderate intensity, as the existing literature demonstrates that MS patients can both tolerate and benefit from this training modality. With circuit training one can perform more work in the same period of time because of better fatigue management and it is a cost effective way to keep fit. Dean et al. [8] conducted a pilot study with chronic stroke, who participated in task related circuit training programme designed to improve strength and endurance of the affected lower limb and functional performance and the patients demonstrated significant improvement after training and also 2 month follow-up compared with the control group.

Ambulatory function is important in day to day life and necessary for successful community participation. Most of the studies used resistance training and found improved waking ability and decreased fatigue of the MS patients. Till date no study was conducted using task related circuit training programme for the improving walking ability of MS subjects. In this study an attempt has been made to investigate the effectiveness of a 12 weeks task related circuit training on walking ability of a multiple sclerosis subject. We hypothesized that the Multiple Sclerosis subject would show improved walking ability after 12 weeks of task related circuit training.

2. Methods

2.1. Participant and history

The subject was a 34 -year-old male who was diagnosed with Multiple Sclerosis (Primary progressive type) by a Neurologist. He was apparently alright one year four month’s back. To start with the subject experienced difficulty maintaining balance while riding bicycle. Gradually, his waking became difficult but he managed walking for long distance. He could not participate in daily functions with satisfaction due to muscle weakness, fatigue and lack of coordination. He was treated by a Neurologist at Bangur Institute of Neurology, Kolkata, West Bengal, India for a period of 6 months and then referred to Department of Occupational Therapy, National Institute for the Orthopaedically Handicapped, Kolkata for further management. His primary concerns were difficulty walking, fatigue and lack of coordination.

2.2. Patient examination

Prior to participation in the study, the subject signed an informed consent. The subject was evaluated for all the outcome measures before the training and 12 weeks after the task-related circuit training. An independent assessor, who was not involved in the study and the treatment of the subject, performed all the tests. The subject was given standard instructions before testing. The subject received encouragement during performance of some of the tests.

Manual Muscle testing (MMT) of Hip flexors, extensors and abductors, Quadriceps, Hamstrings, Plantar flexors and Dorsi-flexors of ankle were done.
Table 1

<table>
<thead>
<tr>
<th>No. of task</th>
<th>Name of task</th>
<th>Duration of task in minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sit to stand from appropriate seat height</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Stepping up and down</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Stair climbing</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Heel raise and lower</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Over ground forward walking</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Walking side ways</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>Walking backward</td>
<td>5</td>
</tr>
</tbody>
</table>

Modified fatigue Impact scale (MFIS) [21] and an Expanded Disability Status scale (EDDS) [14,25] were completed by the subject upon study enrolment and after 12 weeks of task related circuit training. Standard instruction was given to the subject to complete the questionnaires. MFIS has satisfactory reliability and validity [16] in MS population (Intra Class Correlation Coefficient (ICC > 0.84) [23].

2.3. Speed test [12]

Fourteen meter walking was marked on the floor. First and last 2 meters were also marked on the walking. The subject was asked to walk on the 14 meter walking. The First and last two meters were not taken into consideration to exclude the effect of acceleration and deceleration. The distance of middle 10 meter was taken into consideration for calculation of speed. Time was measured by stop watch. Walking speed was calculated by using formula distance / time.

2.4. Timed up and go test [7]

This was used to measure the time taken by the subject to maintain the dynamic postural stability. It was done by asking the subject to stand up from a chair with arm rest. Subject was allowed to walk for 3 meters, turn around, return to chair, then sit down. Time taken to complete the transition was measured by stop watch. Timed Up and Go Test has got good concurrent validity [5] and Intra class correlation coefficient was 0.98 [23].

2.5. Six minute walk test [19]

This was used to measure the endurance. The subject was asked to walk a walkway which was marked in every 5 meter interval. The distance covered in 6 minutes was measured by meters. This is a highly reliable test in ambulatory MS patients. The test retest reliability is r² = 0.97 [11] and Inter rater reliability is very high, (ICC = 0.91) [15].

All the tests were carried out on the same day, excluding the 6 minute Walk Test, which was done the next day to avoid the effects of fatigue on the subject.

3. Intervention

The subject participated in the task related circuit training program for a session of 45 minutes, 3 days per week, for 12 weeks. The circuit class offers a practical and efficient way to promote structured practice of task related activities [2]. The circuit class was conducted in the clinic and the subject was not instructed to practice any of the tasks at home (Table 1).

Before starting of training program the subject had 5 minutes of warm up and after the end of the training 5 minutes of cool down period. The warm up period included 3 minutes of stationary bicycling at a moderate pace and ended with 2 minutes of gentle stretching. The cool down period included stationary bicycling with relatively slow pace for 3 minutes and ended with a series of gentle stretch, holding each stretch with at least 10–20 seconds.

3.1. Sit to stand from appropriate seat height

Initially, the subject was seated on a firm, flat surface seat with no arm rests, feet flat on the floor, with no flexion within upper body throughout action by giving a target to the eyes, which was placed 2–3 meter in front of eye level.

Seat height was selected according to the ability of the subject on a trial and error basis. Subject was instructed to swing his shoulder forward and stand up without leaning forward for greater generation of horizontal momentum. Subject was instructed to direct attention toward the target. Finally, subject was instructed to flex at hip, knee, and ankle to sit from upright standing alignment. Subject was instructed to do it repetitively.
Table 2

<table>
<thead>
<tr>
<th>Muscle tested</th>
<th>Left (pre)</th>
<th>Left (post)</th>
<th>Right (pre)</th>
<th>Right (post)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hip flexors</td>
<td>4−</td>
<td>4+</td>
<td>4</td>
<td>4+</td>
</tr>
<tr>
<td>Hip extensors</td>
<td>3+</td>
<td>4+</td>
<td>4</td>
<td>4+</td>
</tr>
<tr>
<td>Hip abductors</td>
<td>4</td>
<td>4+</td>
<td>4−</td>
<td>4+</td>
</tr>
<tr>
<td>Knee extensors</td>
<td>4−</td>
<td>4+</td>
<td>4</td>
<td>4+</td>
</tr>
<tr>
<td>Knee flexors</td>
<td>4</td>
<td>4+</td>
<td>3+</td>
<td>4</td>
</tr>
<tr>
<td>Ankle Dors- flexors</td>
<td>4</td>
<td>4+</td>
<td>4</td>
<td>4+</td>
</tr>
<tr>
<td>Ankle planar- flexors</td>
<td>4−</td>
<td>4+</td>
<td>4</td>
<td>4+</td>
</tr>
</tbody>
</table>

3.2. Stepping up and down

Subject was standing 15 centimeters away from the 15 centimeter high wooden block. The subject was asked to step up and step down. He was to step up with the first foot, step up with the second foot, then down with the second foot and finally down with the first foot. During this activity subject was instructed to do as fast as possible.

3.3. Stair climbing

Subject was instructed to advance the better leg first then the other foot and during stair descent weaker leg first then the better leg. The subject was instructed to walk reciprocally without any support. The height of the each stair was 10 centimeters.

3.4. Heel raise and lower

The subject was asked to bear weight on forefeet while standing on a stair, remaining the heels free. Heels were lowered as far as possible, then raised again to plantigrade with the hips and knees extended.

3.5. Over ground forward walking

Patient was asked to walk forward starting with body erect with hip in 0 degree neutral position and then to take a forward step. The subject was encouraged to step out and take even steps, then take steps with his maximum speed to gain more symmetry.

3.6. Walking side ways

With feet together, subject was instructed to take step laterally while supporting and balancing the body mass on one leg, then stepping with the other leg, keeping hip in neutral extension while stepping in swing and stance phase.

3.7. Walking backward

The subject was instructed to walk backward starting with one leg stepping backward and completing with the other leg reciprocally.

4. Result

Self reported EDDS score was decreased from 3.5 to 3 after 12 weeks of task-related circuit training. The average MFIS score was decreased from 32 to 24 after the training.

MMT of hip flexors, extensors and abductors, Knee extensors and flexors, planter flexors and dorsi-flexors of both lower limb improved by one grade or half a grade (Table 2).

Walking speed of the MS subject was increased from 0.22 meter per second to 0.26 meter per second post task related circuit training (Table 3).

The time taken for getup and go test was decreased in the subject from 31.76 second to 17.1 second after the 12 weeks of training (Table 4).

The distance walked by the subject was increased from 117.1 meter to 243.07 meter post task related circuit training (Table 5).

5. Discussion

The purpose of this case study was to see the effect of 12 weeks task related circuit training on walking ability of a Multiple Sclerosis patient based on the evidence, that resistance training improves walking ability of Multiple Sclerosis patient and added purpose to exercise or tasks, designed to improve strength can have a positive effect on walking ability in Multiple Sclerosis. The result supports the efficacy of task-related circuit training for this patient. In this study, the task related practice (with at least body weight or weight of a limb as resistance), as in repeated standing up and sitting down, helped in increasing muscle strength of lower
extremity (increased force generating capacity). Increased muscle strength occurs due to improved firing and synchronization of motor units and improved agonist antagonist and synergic coordination. Task related exercises have therefore the potential to increase the control of movement and functional performance of the everyday actions which are the focus of the exercise [3].

The sit to stand task helped in improving muscle strength of Hip and knee extensors, Ankle Dorsiflexors and repeated sitting to standing helped in improving the length of the Soleus muscle [4].

During ascent (stair climbing task) stance phase, weight acceptance is initiated with middle to front portion of foot, pull up occurs through the extensor activity at the knee, ankle, primarily concentric contraction of vastus lateralis and soleus and in forward continuity phase ankle generates forward and lift forces. In swing phase, foot clearance is activated through activation of dorsiflexors and activation of hamstrings which flex the knee. The Rectus femoris contracts eccentrically to reverse the motion by mid swing. The swing leg is brought up and forward through activation of hip flexors of the swing leg and motion of the contra lateral stance leg. Final foot placement is controlled by hip extensor and ankle dorsiflexor. Decent (walking down stairs) is achieved through eccentric contraction of Knee extensors and planter flexors [4].

Step up and step down task trains hip, knee and ankle extensors to work together both concentrically and eccentrically, to raise and lower the body mass. Step up exercises also train ankle dorsiflexors.

Heel raise and lower task helped in improving the planter flexor strength which is the major power generator during the gait cycle during push off [18].

The hip abductors improved in power due to side wise walking task and walking back ward task strengthens hip extensor activity particularly hamstrings.

Self reported fatigue was reduced in the patient who was assessed by using MFIS following task related circuit training, which indicates that Task related circuit training may be beneficial in reducing fatigue as improved strength in the individual with MS can enhance
functional reserve, thus making daily activities less fatiguing. The results are supported by the study done by White et al. [28].

The self reported disability status reduced in the patient may be attributed to the increased muscle strength and improvement of average physical fitness of the patient. This is supported by the study done by White et al. [23] using resistance training for improving strength and functional capacity of MS patients and their study showed decrease in self reported disability in all subjects following the exercise program.

The patient had showed improvement in 6 minute walk test which may be due to increased VO2 Max as well as increased muscle strength and physical fitness after training which is reduced in patients with MS [3]. The patient reported greater level of comfort ability in day to day activities.

This overall improvement in muscle strength, endurance and reduced fatigue helped in improving gait velocity and the ability to walk after task related circuit training, which is supported by the study of Dean et al. [7] with stroke patients. The increase in speed may be due to increase in strength of ankle planter flexor, hip extensor and flexors. Planter flexor and hip flexors is the major power generator for push up and pull-up during propulsion. There is increasing evidence that the effects produced by strengthening programs may generalize to higher gait speeds, increased gait endurance and improved Activities of daily living [8,24,27]. Added purpose of task related circuit training can enhance performance compared to rote exercise [29]. In addition it found in other studies by Richards et al., and Dean et al. that training programs in which patients are subjected to high repetitions of functional activities are more likely to improve in function than conventional strengthening of lower limb [24,27]. The subject himself provided comments after completion of the training and the comments suggests that the training program was simple to follow and the tasks included can be practiced easily.

6. Conclusion

The result of the study provides evidence, that task related circuit training can be used to improve the walking ability in multiple sclerosis. Use of tasks helped improving muscle strength of lower limb, endurance and reduced fatigue of the subject thereby improving the walking ability. There were certain limitations of the study. As the tasks were common day to day activities, subject might have used those tasks at home leading to improvement in some outcome measures. There could be potential influencing factors like examiner error, motivation level of the subject and encouragement during test performance for the small gains noted in the outcome measures. No follow up was done, so sustainability of the effect of the training could not be evaluated. A larger sample may be considered to investigate the effectiveness of the training programme in future.

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